

SIMULTANEOUS OBSERVATIONS OF CHANGES IN CORONAL BRIGHT POINT EMISSION AT THE 20 cm RADIO AND He λ 10830 WAVELENGTHS

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INTRODUCTION

Coronal bright points are the smallest scale closed coronal structures that have been observed so far on the Sun (e.g. Golub *et al.*, 1974). They are associated with ephemeral magnetic bipolar regions (i.e. regions of opposite magnetic polarities) with lifetimes of hours (e.g. Harvey *et al.*, 1975). In x-ray spectroheliograms, coronal bright points appear to be collections of miniature loops or arches, typically 2500 km in diameter and 12,000 km in length (Sheeley and Golub, 1979). They are also characterized by significant changes over a few minutes in the intensity of emission from the plasma confined within the magnetic field forming these structures.

A detailed study of the extreme ultraviolet (EUV) data from Skylab (Habbal and Withbroe, 1981) showed that, over a period of 5 min, the shortest time scale available from the data, strong temporal and spatial variations in intensity of emission occur in the chromospheric through coronal layers of the bright points. Habbal and Withbroe (1981) attributed the changes in EUV emission to intermittent heating, possibly correlated with changes in magnetic field topologies over very small scales (few arcsec or less). More recently, Harvey (1985) has shown that, features which appear as "dark" absorption regions in the He I λ 10830 line (typically 15 to 20% darker than the average network) and believed to be the photospheric counterpart of coronal bright points, are often associated with encounters of existing opposite polarity magnetic regions rather than emerging magnetic flux. In He I λ 10830 they are also observed to be short lived ($<$ hours), often appearing and disappearing over a few minutes.

Recent radio observations acquired with the VLA at 20 cm wavelength showed that bright points appear as localized 20-40" radio sources, clearly distinguishable from the surrounding quiet sun (Habbal *et al.* 1986). At the 20 cm wavelength, the radio emission from bright points arises mainly from heights typical of the low corona-transition region. The bright points exhibit substantial spatial and temporal variations in radio emission over time scales as short as 2 minutes, very similar in nature to the variability observed in earlier studies at x-ray, EUV and optical wavelengths. Analysis of the data showed that the fluctuations observed in the radio emission are most likely due to intermittent heating.

OBSERVATIONS

We report here on preliminary results of observations of solar coronal bright points acquired simultaneously from ground based observatories at the radio wavelength of 20 cm and in the He I λ 10830 line on September 8, 1985. The impetus for obtaining simultaneous radio and optical data is (1) to identify correlations, if any, in changes of the low transition-coronal signatures of bright points with the evolution of the magnetic field, and (2) to distinguish between intermittent heating and changes in the magnetic field topology. Although simultaneous observations of H α emission and the photospheric magnetic field at Big Bear (S. Martin) were also made, as well as radio observations from Owens Valley Radio Interferometer (with G. Hurford) and SMM (O VIII line), we present here only a comparison between the He 10830 and VLA radio data.

The correspondence found between compact (20-40") radio sources observed at 20 cm with the VLA and the He I λ 10830 dark points is shown in Figure 1. The existence of an active region in the South East, and a smaller one close to Sun center made the superposition of the radio maps with a full disk He 10830 spectroheliogram particularly accurate. In the 512"x512" area around Sun center where the high temporal resolution He 10830 observations were made, the radio sources were found to coincide with He 10830 dark points. The spatial resolution is 1-2" in the He and 16" in the radio. There were, however, more He 10830 dark points than radio sources. The radio bright points with a dashed and a solid contour are those observed to last longer than 2 hours in the approximately 5 hours of simultaneous observations. The solid line contours represent shorter lived features (at least one hour). Comparison with high resolution magnetograms confirms that the radio bright points coincide with bipolar regions.

Shown in Figure 2 are the changes in time of the maximum radio brightness temperature and the absolute value of the maximum intensity of absorption in the He 10830 of one of the sources, source A. (0 min on the time axis corresponds to 16:00 UT). The time interval is 3 min, which is the time required to make a 512"x512" scan in the He line. Radio maps were made at the exact corresponding time intervals. The data gaps in the radio data correspond to the pointing of the antennas to the calibration source; also no radio maps were made in the He 10830 data gaps 17:56 - 18:23 and 20:15 - 20:41 UT. Sporadic variations in the emission (absorption) often occur at the shortest (3 min) time interval. (These variations are significant when greater than 10% in the intensity of absorption in the He λ 10830 and greater than 10^4 K in the radio brightness temperature). The temporal changes in the simultaneous observations are often correlated, but there are a few cases, for example between 19:00 and 19:30 or between 19:50 and 20:00, when the radio emission and He absorption are anticorrelated.

DISCUSSION

One of the striking features of bright points observed so far at different wavelengths is the spatial variation of the region of maximum emission (or absorption), i.e. the bright (dark) "patch" does not remain uniform but rather brightens in certain spots while others dim, also a bright point can completely fade and reappear rather suddenly at a later time (see, for example, Habbal and Withbroe 1981, and Habbal *et al.* 1986). Hence it is clear that these features are responding rather rapidly to dynamic effects. At the time of this writing a quick look at the magnetograms shows that at least 80 % of the radio sources correspond to areas of disappearing flux, i.e. where magnetic regions of opposite polarity approach each other and cancel. Very few are associated with new emerging flux. There are five bright points that overlie regions where some flux cancelling is occurring while new flux also emerges in the neighborhood. Hence this suggests that the magnetic field is playing an important role in the observed dynamic behavior of the bright points. On the other hand one of the plasma variables that can account for variations observed at the radio wavelength and the He 10830 absorption is the density. Density fluctuations caused by intermittent heating or from the interaction or roping around of the field lines could easily account for the sporadic nature of the variability in emission (absorption).

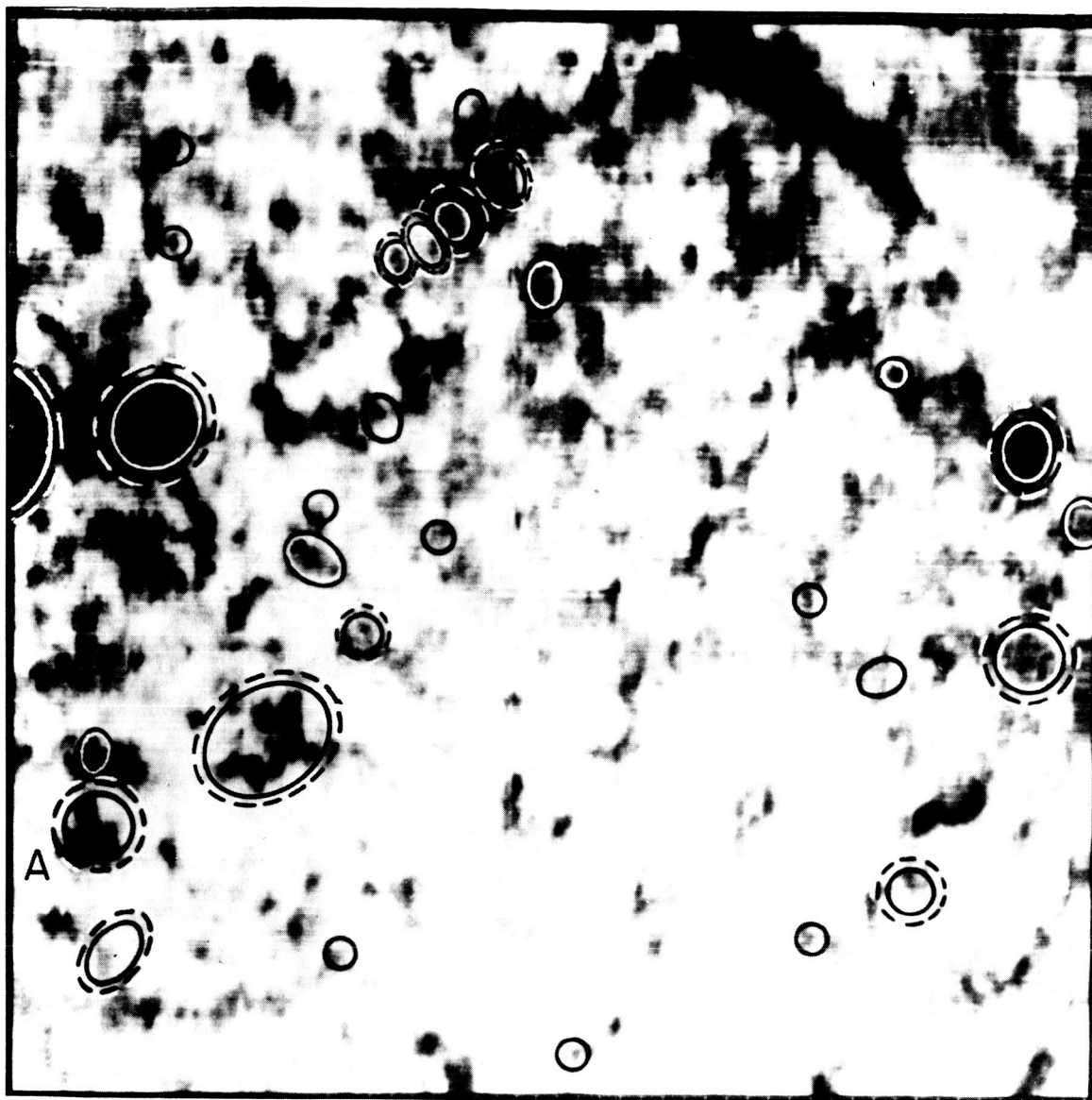


Figure 1: Overlay of radio sources, observed with the VLA at 20 cm, on a He λ 10830 spectroheliogram. The observations were made simultaneously on September 8, 1985. The field of view of the He λ 10830 spectroheliogram is $512'' \times 512''$, centered at Sun center at 16:00 UT. Radio sources indicated by two contours were present for at least 2 hours in the observing sequence of 5 hours. Shorter lived radio sources are indicated by one contour.

SOURCE A

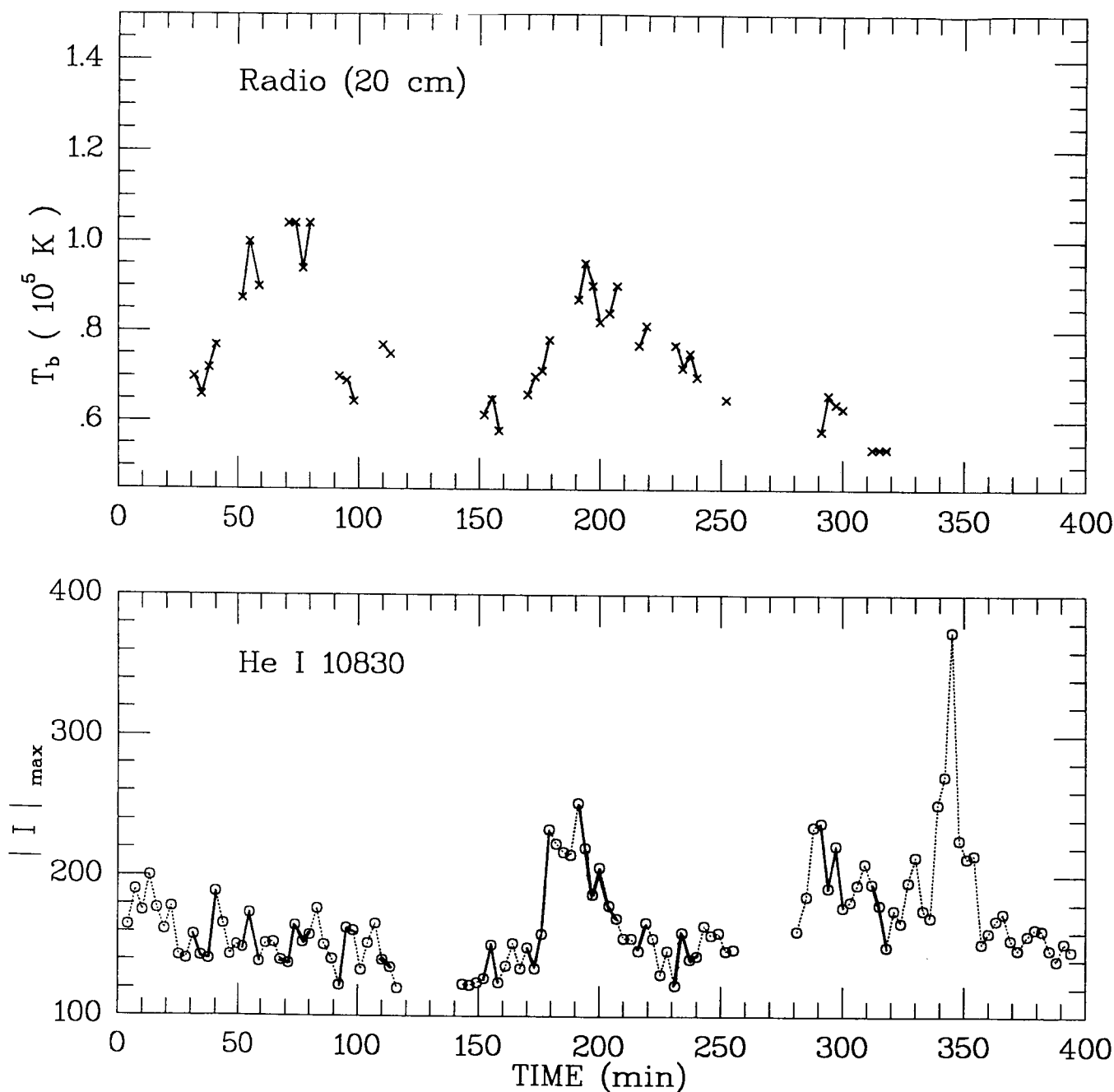


Figure 2: Changes in time of the absolute value of the maximum absorption ($|I|_{\max}$) in $\text{He } \lambda 10830$ and the maximum brightness temperature (T_b) of the radio emission at 20 cm for Source A. The solid lines at both wavelengths indicate simultaneous continuous observations with 3 min integration time. The dotted lines in the $\text{He } \lambda 10830$ connect data points with no corresponding radio data. The short data gaps in the radio correspond to the pointing of the antennas to the calibration source. Two data gaps exist in the $\text{He } \lambda 10830$ data: 116-143 (or 17:56-18:23 UT), and 255-281 (or 20:15-20:41 UT), when no radio data are shown either.

CONCLUSION

Radio observations are an important component in the study of coronal bright points because they are, at present, the only means to explore the transition region-corona heights from the ground with high temporal and spatial resolution. Furthermore, radio measurements can also be used to derive quantitative information regarding important solar plasma parameters such as the magnetic field strength, plasma density and electron temperature. For example, field strengths of the order of 50 to 100 G at the low corona-transition region height in bright points have been deduced for the first time from radio observations (Habbal *et al.* 1986). The radio observations will provide valuable quantitative information about the hot plasma in bright points while the optical data will provide information about the chromospheric and low chromospheric-coronal transition region and the photospheric magnetic field.

The intriguing questions that arise with respect to the behavior of bright points are directly related to the fundamental problem of coronal heating. If bright points are part of the same class of phenomena as active regions, but on a smaller scale, then the understanding of their behavior will shed light on the question of solar activity. Coronal bright points seem to offer an ideal candidate to explore the role of the magnetic field in the heating of the plasma, and the evolution of the field in time.

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REFERENCES

- Golub, L., Krieger, A. S., Vaiana, G. S., Silk, J. K., and Timothy, A. F. 1974, "Solar X-Ray Bright Points," *Astrophys. J.*, **189**, L93.
- Habbal, S. R. and Withbroe, G. L. 1981, "Spatial and Temporal Variations of EUV Coronal Bright Points," *Solar Phys.*, **69**, 77.
- Habbal, S. R., Ronan, R. S., Withbroe, G. L., Shevgaonkar, R., K. and Kundu, M. 1986, "Solar Coronal Bright Points Observed with the VLA," *Astrophys. J.* in press, July 15.
- Harvey, K. L., Harvey, J. W., and Martin, S. F. 1975, "Ephemeral Active Regions in 1970 and 1973," *Solar Phys.*, **40**, 87.
- Harvey, K. L. 1985, "The Relationship between Coronal Bright Points as seen in He I λ 10830 and the Evolution of the Photospheric Network Magnetic Field," *Australian J. of Physics*, **38**, 875.
- Sheeley, N., R. Jr., and Golub, L. 1979, "Rapid Changes in the Fine Structure of a Coronal Bright Point and a Small Active Region," *Solar Phys.*, **63**, 119.